

tropic, and a diamond.\* Mr. Spencer thinks that the colourless birefringent fragments are perhaps optically uniaxial, and that they may very well be corundum.† The browner grains he suggests are also diamonds. In favour of this identification is the fact that small diamonds occur at the Newlands Mine (I have seen some in Mr. Trubenbach's hands), rather ovoid in shape, with a roughened surface, some a yellowish-brown, some colourless. But against it we may urge that they appear to have been destroyed during the second treatment.‡ Be this as it may, Sir W. Crookes has succeeded in showing that microscopic diamonds do occur in the eclogite, which contains those of larger size.

To conclude : in addition to this residue from the eclogite we have ascertained (1) the existence, in some quantity and variety, of pre-triassic diabase,§ (2) the abundant development of a microscopic brown mica in the ground mass of the so-called kimberlite ; (3) the presence in it, as true boulders, of at least four more species of holocrystalline rock. The last fact acquires an additional importance, because, since the publication of my former paper, the boulders therein described have been claimed as "concretions" in the so-called kimberlite.|| With this matter I have dealt elsewhere,¶ but the identification of seven species or strongly-marked varieties of holocrystalline rocks, peridotites, eclogites, &c., in which the minerals at the surface are worn as if by the action of water, not to mention the general structure of the so-called kimberlite, must, I think, offer insuperable difficulties even to the most enthusiastic advocate of concretionary action.

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"The Distribution of Vertebrate Animals in India, Ceylon, and Burma." By W. T. BLANFORD, LL.D., F.R.S. Received December 3,—Read December 13, 1900.

(Abstract.)

Several contributions on the subject of the distribution of Vertebrata, or geographical Zoology, in India and the neighbouring countries

\* On re-examining the specimen, now that Mr. Spencer has kindly mounted it in a better position, I agree with this determination.

† On a final examination of the slides, I find among them one if not two small grains which I strongly suspect to be diamonds.

‡ A final examination and comparison with some bits of "bort" given me by Mr. Trubenbach has not made me more favourable to my original identification with rutile.

§ That is, at any rate, older than the time when the Karoo series was deposited.

|| Professor Beck, 'Zeitschrift für Praktische Geol.,' December, 1899.

¶ 'Geol. Mag.,' 1900, p. 246.

have been made by Elwes,\* von Pelzeln,† Wallace,‡ Sharpe,§ Newton,|| Gadov,¶ Lydekker,\*\* and W. Selater,†† besides the present author.‡‡ The majority of these contributions deal, however, with birds or mammals alone, the first-named class having received the greatest amount of attention.

The completion of the seven volumes containing descriptions of all the Vertebrata, in the 'Fauna of British India,' affords an opportunity of reviewing generally the distribution of terrestrial vertebrate animals throughout the British possessions in India, Ceylon, and Burma. The limits are those of the British Indian territories and dependencies with the addition of Ceylon (which, although British, is not under the Indian Government). Baluchistan, all the Kashmir territories (with Gilgit, Ladāk, &c.), Nepal, Sikhim, Bhutan, and other Cis-Himalayan States, Assam, Manipur, the Burmese Shan States, Karennee, and the Andaman and Nicobar Islands are included; but not Afghanistan, Kashgaria, Tibet, Yunnan, Siam, or the Malay Peninsula south of Tenasserim.

For the study of zoological distribution there are few, if any, regions on the earth's surface that exceed British India and its dependencies in interest. The area is about 1,800,000 square miles, and although the vertebrate fauna is by no means thoroughly explored, it is well known throughout the greater part of the area and fairly known throughout the whole, better probably than in any other tropical and sub-tropical tract of approximately equal extent. The variety of climate is remarkable; within the area are included the almost rainless deserts of Sind and the locality on the Khāsi Hills distinguished by the heaviest rainfall known, the cold arid plateau of the Upper Indus drainage, and the damp tropical forests of Malabar and Tenasserim. The country is bounded on the north by the highest mountain range in the world, and on the south by an ocean extending to the Antarctic regions. Another element of interest lies in the fact that the peninsula of India is a land of great geological antiquity, there being no evidence that it has ever been submerged, although the greater part of the Himalayas and Burma have at times been beneath the sea.

The plan adopted for the study has been to divide the whole country

\* 'P. Z. S.,' 1873, p. 645.

† 'Africa-Indien,' "Verh. Z.-B. Ges. Wien," 1875, p. 62.

‡ 'Geographical Distribution,' vol. 1, pp. 81, &c., 1876.

§ 'Natural Science,' August, 1893, p. 108.

|| 'Dictionary of Birds,' p. 358 (1893).

¶ Bronn's 'Kl. Ord. d. Thierreichs,' VI, 4, Vögel, p. 296 (1893).

\*\* 'Geographical History of Mammals,' p. 266 (1896).

†† 'Geographical Journal,' 1896, vol. 8, p. 380; 'Geography of Mammals,' p. 131.

‡‡ 'Jour. As. Soc. Beng.,' vol. 39, pt. 2, p. 336 (1870); 'A. M. N. H.' (4), vol. 18, p. 277 (1876); Introduction to "Mammalia," 'Fauna Brit. Ind.,' p. IV (1888).

into nineteen tracts, distinguished by physical characters such as rainfall, temperature, presence or absence of forests, and prevalence of hilly ground, and to construct tables showing the distribution of each genus of land or fresh-water vertebrate in the tracts. Genera have been selected for consideration, because families and sub-families are too few in number and too wide in range, whilst species are too numerous and too unequal in importance. It is recognised that there is much difference in the value of genera in different groups, the generic differences in passerine birds, for instance, being as a rule of inferior rank to those in some other orders of birds, or to those generally adopted amongst mammals, reptiles, and batrachians. In the demarcation of regions and sub-regions, terrestrial mammalia are regarded as of primary importance.

The tracts are the following :—

#### *A. Indo-Gangetic Plain.*

1. Punjab, Sind, Baluchistan, and Western Rajputana.
2. Gangetic Plain from Delhi to Rajmahal.
3. Bengal from Rajmahal to the Assam Hills.

#### *B. Indian Peninsula.*

4. Rajputana and Central India as far south as the Nerbudda.
5. Deccan from the Nerbudda to about 16° N. lat. and from the Western Ghats to long. 80° E.
6. Behar, Orissa, &c., from the Gangetic Plain to the Kistna.
7. Carnatic and Madras, south of 5 and 6, and east of the Western Ghats.
8. Malabar Coast; Concan, and Western Ghats or Sahyadri range from the Tapti River to Cape Comorin.

#### *C. Ceylon.*

9. Northern and Eastern Ceylon.
10. Hill Ceylon, the Central, Western, and Southern Provinces.

#### *D. Himalayas.*

11. Western Tibet and the Himalayas above forest.
12. Western Himalayas from Hazara to the western frontier of Nepal.
13. Eastern Himalayas, Nepal, Sikhim, Bhutan, &c.

E. Assam and Burma.

14. Assam and the hill ranges to the south, with Manipur and Arrakan.
15. Upper Burma, north of about 19° N. lat.
16. Pegu from the Arrakan Yoma to the hill ranges east of the Sittang.
17. Tenasserim as far south as the neighbourhood of Mergui.
18. South Tenasserim, south of about 13° N. lat.
19. Andaman and Nicobar Islands.

A review of the fauna of these tracts leads to the following conclusions:—

I. The Punjab tract differs greatly in its fauna from the Indian peninsula and from all countries to the eastward, so greatly that it cannot be regarded as part of the Indo-Malay or Oriental region. Of terrestrial mammals, bats excluded, 30 genera are met with, of which 8 or 26½ per cent. are not Indian, whilst of reptiles (omitting crocodiles and chelonians) 46 genera occur, and of these 20 or 43½ per cent. are unknown further east. Of the corresponding orders of mammalia 46, and of reptiles 80 genera occur in the Peninsula, and 24 or 52 per cent. of the former and 57 or 64 per cent. of the latter are not found in the Punjab tract. The differences would be larger but for the fact that certain genera, for instance, *Antelope* and *Boselaphus* (nilgai), are found east of the Indus though not further west, and that a few Indian species straggle into the Punjab area. All the genera met with in the Punjab tract and wanting farther east are either Holarctic forms or peculiar, but with Holarctic affinities.

The Punjab, Sind, and Western Rajputana are in fact the eastern extremity of the area known as the Eremian or Tyrrhenian or Mediterranean sub-region, generally regarded as part of the Holarctic region, but by some classed as a region by itself corresponding to the Sonoran in North America.

II. The Himalayas above the forests and such portions of Tibet as come within Indian political limits (Gilgit, Ladák, Zaskar, &c.) belong to the Tibetan sub-region of the Holarctic region. Of twenty-five mammalian genera hitherto recorded from No. 11 (the Tibetan) tract, 11 or 44 per cent. are not found in the Indo-Malay region. That Tibet forms a distinct mammalian sub-region has already been shown in other papers.\*

III. India proper from the base of the Himalayas to Cape Comorin, and from the Arabian Sea and the eastern boundary of the Punjab tract to the Bay of Bengal and the hills forming the eastern limit of the Gangetic alluvium, should, with the addition of the island of

\* 'Geol. Mag.,' 1892 (3), vol. 9, p. 164; 'P. Z. S.,' 1893, p. 448.

Ceylon, be regarded as a single sub-region, and may be conveniently entitled the Cisgangetic sub-region.\* The forests of the Sahyādrī range and of the Western or Concan and Malabar coast and the hill area of Southern Ceylon have a far richer fauna than the remaining area, but are not sufficiently distinct to require sub-regional separation.

The hill fauna of the Sahyādrī range, especially on the highest portions, such as the Nilgiri and Anaimalai Hills, and that of the hill group in South-western Ceylon, contain several Himalayan genera and species, but not sufficient to enable the S. Indian and Ceylonese areas to be classed with the Himalayan forest area in a separate sub-division or sub-region.

The Cisgangetic sub-region is distinguished from the Transgangetic by the presence amongst mammals of Hyænidæ, Erinaceinæ, Gerbilinæ, of three peculiar genera of Antelopes and of some other types; amongst birds by the occurrence of Pterocletes (sand grouse), Phœnicopteri (flamingoes), Otididæ (bustards) and Cursoriinæ; amongst reptiles by the possession of the families Eublepharidæ, Chamæleontidæ and Uropeltidæ, together with many peculiar Geckonidæ, Agamidæ and Lacertidæ, and amongst batrachians by about one-half of the genera found in each sub-region being absent in the other. The difference between the reptiles and batrachians by itself would justify the classification of the two areas as distinct regions, a view adopted by several writers.

The following figures show the total number of genera recorded from the Cisgangetic sub-region and the percentage of them not ranging into the Transgangetic area, the Himalayas and Burma:—

	Cisgangetic.	Not Transgangetic.
Mammals .....	62	14 or 22·5 per cent.
Birds .....	347	46 or 13     „
Reptiles .....	93	39 or 42     „
Batrachians .....	17	9 or 53     „
Freshwater fishes ...	58	9 or 15·5     „

Omitting bats, the number of Cisgangetic mammalian genera is forty-six, of which 14 or 30 per cent. are wanting in the Himalayas and east of the Bay of Bengal.

The difference between the Cisgangetic vertebrate fauna and that inhabiting the rest of the Indo-Malay or Oriental region is partly due to the absence in the former of numerous Eastern types, and partly to the presence of two constituents besides the Oriental genera, which, especially in forest, form a majority of the animals present. One of these two constituents consists of mammals, birds, and reptiles having

\* The terms "Cisgangetic" and "Transgangetic" have already been employed by Professor Gadow, *l.s.c.*

a distinct relationship with Ethiopian and Holarctic genera, and with the Pliocene Siwalik fauna. This constituent of the Cisgangetic fauna it is proposed to distinguish by the term Aryan. The other constituent is composed of reptiles and batrachians, and may be termed the Dravidian element. The latter is well developed in the south of the Peninsula and especially along the south-west or Malabar Coast, and in Ceylon, but it gradually disappears to the northward, its northern limit, so far as is known at present, not extending to the 20th parallel of north latitude. It is probable that this is the oldest part of the Cisgangetic fauna, and it may have inhabited the country since India was connected by land with Madagascar and South Africa, across what is now the Indian Ocean, in Mesozoic and early Cenozoic times. The other two elements, the Indo-Malay or Oriental and the Aryan, are probably later immigrants, and its wider diffusion may indicate that the Oriental element has inhabited the Indian Peninsula longer than the Aryan has. There appears some reason for regarding the Oriental portion of the fauna as dating in India from Miocene times and the Aryan from Pliocene, whilst in the Pleistocene epoch the proportion of Aryan to Oriental types of mammals in India, as shown by the fossil faunas of the Nerbudda and the Karnul Caves, was much larger than at the present day.

There are some other peculiarities of the Indian Peninsular fauna to which attention may be called. One of these is the presence of genera and sometimes of species which are found on both sides of the Bay of Bengal, but not in the Himalayas or Northern India. A good example is afforded by the genus *Tragulus*, of which one species inhabits Ceylon and India south of about 22° N. lat. whilst two others are found in Southern Tenasserim and the Malay Peninsula. In Pliocene times, the genus inhabited Northern India. Another instance is the lizard *Liolepis guttatus* found in Burma and Arrakan, and also in South Canara on the West Coast of India. Examples amongst reptiles are rather numerous. Moreover, whilst there are numerous alliances between the animals of Peninsular India and those of Africa, there are also some curious connections between India and Tropical America, but these are chiefly amongst invertebrates. Some, however, are found in reptiles. It is probable that such Indo-American connections are vestiges of older life than the Indo-African. They are of course, generally speaking, instances of animal groups once more widely distributed, but now only preserved in a few favourable tropical localities.

IV. The forest area of the Himalayas belongs to the same sub-region as Assam, Burma (except South Tenasserim), Southern China, Tonquin, Siam, and Cambodia, and to this sub-region the term Transgangetic may be applied. It is distinguished from the Cisgangetic sub-region by the absence of the animals already specified as characteristic of that

area and by the presence of the following, which are wanting in the Indian Peninsula—Mammals: the families Simiidae, Procyonidae, Talpidae, and Spalacidae, and the sub-family Gymmurinae, besides numerous genera, such as *Prionodon*, *Helictis*, *Arctonyx*, *Atherura*, *Nemorhaedus*, and *Cemas*. Birds: the families Eurylamidae, Indicatoridae, and Heliornithidae, the sub-family Paradoxornithinae. Reptiles: Platysternidae and Anguidae. Batrachians: Discophidae, Hyliidae, Pelobatidae, and Salamandridae.

The following are the numbers of the genera in the different classes recorded from the Indian portion of the Transgangetic region, but not from the Cisgangetic :—

	Transgangetic.	Not Cisgangetic.
Mammals .....	74	26 or 35 per cent.
Birds .....	475	174 or 36·5 „
Reptiles .....	84	30 or 35·5 „
Batrachians .....	16	8 or 50 „
Freshwater fishes ...	67	18 or 27 „

Omitting bats, the number of Transgangetic mammals within Indian limits are fifty-four, of which 22 or 40 per cent. are not Cisgangetic.

The relations of the Himalayan fauna to that of Assam and Burma on the one hand and to that inhabiting the Peninsula of India on the other may be illustrated by the mammals with bats omitted. Of forty-one genera occurring in the Himalayas, three are not found in the hills south of Assam or in Burma, whilst sixteen are wanting in the Cisgangetic region. It should be remembered that a large number of the genera are widespread forms. As the result is not in agreement with the views of some who have written on the subject, the relations of species have been examined. It results that eighty-one species of mammalia belonging to the orders Primates, Carnivora, Insectivora, Rodentia, and Ungulata are recorded from the forest regions of the Himalayas. Of these 2 are doubtful, 22 are not known to occur south of the Himalayan range in India or Burma, 21 are wide ranging forms and are found in both Burma and the Indian Peninsula, 1 only (*Hystrix leucura*) is common to the Himalayan forests and the Indian Peninsula, but does not range east of the Bay of Bengal, whilst 35 are found in the countries east of the Bay of Bengal, but not in the Peninsula south of the Ganges. Of the 35, 8 only range as far as the hills south of the Assam Valley, 16 to Burma proper, and 11 to the Malay Peninsula and Archipelago. Or, in other words, of the 79 Himalayan species, 56 or 70 per cent. are common to the Transgangetic region, and only 22 or 28 per cent. to the Cisgangetic. Of the 22 species not ranging south of the Himalayas a large majority are either Holarctic species or belong to Holarctic genera.

The fauna of the Himalayan forest area is partly Holarctic, partly Indo-Malay. It is remarkably poor, when compared with the Cisgan-

getic and Burmese faunas, in reptiles and batrachians. It also contains but few peculiar genera of mammals and birds, and almost all the peculiar types that do occur have Holarctic affinities. The Oriental element in the fauna is very richly represented in the Eastern Himalayas and gradually diminishes to the westward, until in Kashmir and farther west it ceases to be the principal constituent. These facts are consistent with the theory that the Oriental constituent of the Himalayan fauna, or the greater portion of it, has migrated into the mountains from the eastward at a comparatively recent period. It is an important fact that this migration appears to have been from Assam and not from the Peninsula of India.

V. Southern Tenasserim agrees best in its vertebrata with the Malay Peninsula, and should be included in the Malayan sub-region of the Indo-Malay region.

The continental area of the Indo-Malay or Oriental region is divided into three sub-regions, Cisgangetic, Transgangetic, and Malayan.

There are several points left which require explanation. There is the much greater richness of the Oriental constituent in the Cisgangetic fauna to the southward in Malabar and Ceylon, although this is far away from the main Oriental area, and the occurrence also in the southern part of the Peninsula of various mammalian, reptilian, and batrachian genera, such as *Loris*, *Tragulus*, *Draco*, *Liolepis*, and *Leulus*, which are represented in Burma and the Malay countries but not in the Himalayas or Northern India. In connection with this the limitation of the Dravidian element to the south of India should also be remembered. Then there is the occurrence of certain Himalayan species on the mountains of Southern India and Burma, and even farther south, but not in the intervening area. There is also the predominance of the Western, or what I have proposed to call the Aryan, element in the Pleistocene fauna of the Nerbudda Valley, and of Karnul in the north of the Carnatic tract. Lastly we have to account for the apparently recent immigration of Oriental types into the Himalayas.

Whilst it is quite possible that other explanations may be found, it is evident that all these peculiarities of the Indian fauna may have been due to the Glacial epoch. The great terminal moraines occurring at about 7000 feet in Sikhim, first discovered by Sir J. Hooker,\* whose observations have been confirmed by myself† and others, and the occurrence of similar moraines and other indications of ice action at even lower levels in the Western Himalayas,‡ clearly show that the temperature of the mountain range must have been much

\* 'Himalayan Journals,' vol. ii, pp. 7, &c.

† 'Jour. As. Soc., Berg.,' xl, 1871, Pt. 2, p. 393.

‡ 'Manual of the Geology of India,' Ed. 1, p. 373; Ed. 2, p. 14, and references there quoted.



lower than at the present day when no glacier in Sikkim is known to descend much below 14,000 feet.

During the coldest portion of the Glacial epoch, a large part of the higher mountains must have been covered by snow and ice, and the tropical Oriental fauna which had occupied the range, and which may have resembled that of the Indian Peninsula more than is the case at present, must have been driven to the base of the mountains or exterminated. The Holarctic forms apparently survived in larger numbers. The Assam Valley and the hill ranges to the southward would afford in damp, sheltered, forest-clad valleys and hill slopes a warmer refuge for the Oriental fauna than the open plains of Northern India and the much drier hills of the country south of the Gangetic plain. The Oriental types of the Peninsula generally must have been driven southwards, and some of them, such as *Loris* and *Tragulus*, which must originally have been in touch with their Burmese representatives, have never returned. It was probably during this cold period that the ossiferous Nerbudda beds and the deposits in the Karmul caves were accumulated. The tropical damp-loving Dravidian fauna, if it inhabited Northern India, must have been driven out of the country. Unless the temperature of India and Burma generally underwent a considerable diminution, it is not easy to understand how plants and animals of temperate Himalayan types succeeded in reaching the hills of Southern India and Ceylon, as well as those of Burma and the Malay Peninsula.

When the whole country became warmer again after the cold epoch had passed away, the Transgangetic fauna appears to have poured into the Himalayas from the eastward. At the present day the comparatively narrow Brahmaputra plain in Assam is far more extensively forest-clad, especially to the eastward, than is the much broader Gangetic plain of Northern India, and if, as is probable, the same difference between the two areas existed at the close of the Glacial epoch, it is easy to see how much greater the facilities for the migration of a forest-haunting fauna must have been across the Brahmaputra Valley than over the great plain of the Ganges. This difference alone would give the Transgangetic fauna of Burma an advantage over the Cisgangetic fauna in a race for the vacant Himalayas, even if the latter had not been driven farther to the southward than the former, as it probably was during the Glacial epoch.

The theory, however, is only put forward as a possible explanation of some remarkable features in the distribution of Indian vertebrates. At the same time it does serve to account for several anomalies of which some solution is necessary. If thus accepted, it will add to the evidence, now considerable, in favour of the Glacial epoch having affected the whole world, and not having been a partial phenomenon induced by special conditions, such as local elevation.

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